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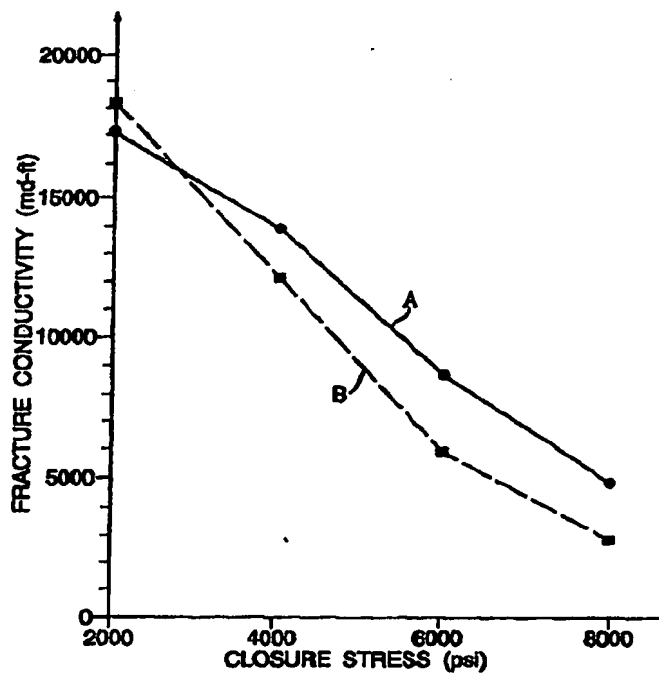
## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(54) Title: WELL TREATMENT FOR WATER RESTRICTION

## (57) Abstract

An oil or gas well is treated to reduce the proportion of water produced by the well, by subjecting the well to a fracture treatment with proppant particles whose conductivity decreases when they are contacted by water. The particles may be of a ceramic material, and may be coated on their external surfaces with a water-soluble chemical; if the proppant particles are porous, they may also be impregnated with the water-soluble chemical. When contacted with water the permeability of a bed of such particles decreases, because the particles become slightly smaller and/or weaker. The chemical might be a water-soluble polymer or a scale inhibitor.



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Well Treatment for Water Restriction

This invention relates to a method for treating an oil or gas well so as to restrict the inflow of water.

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Oil and gas wells extend through subterranean formations, some of which are fluid permeable and contain oil or gas. The oil or gas-containing formation may also contain water, or in some cases water may be injected  
10 into such a formation by a well operator to displace other fluids. Consequently water may flow into the well along with the oil or gas, the proportion of water varying through the formation. Where a formation is insufficiently permeable it is known to enhance its  
15 permeability by subjecting it to a fracturing treatment and injecting proppant particles. This will increase the permeability of the formation to any fluids present.

According to the present invention there is provided  
20 a method of treating an oil or gas well so as to reduce the proportion of water produced by the well, the method comprising subjecting the well to a fracture treatment with proppant particles whose conductivity decreases when they are contacted by water.

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The proppant particles may be coated on their external surfaces with a water-soluble chemical such as a scale inhibitor. In this case the particles may be either porous or non-porous. Alternatively the proppant  
30 particles might be porous, impregnated with a water-soluble chemical, such that the proppant particles are progressively crushed as the chemical is dissolved. The particles in either case may be of a ceramic material, and are preferably of size in the range 0.3 mm to 5 mm,  
35 more preferably between 0.5 mm and 2.0 mm, for example

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about 0.5 mm or about 1.0 mm. It is usually desirable to have all particles of substantially the same size.

It will be appreciated that the water-soluble  
5 chemical may be one which has no appreciable effect on any chemical processes within any well. Alternatively it may be a chemical which would suppress a deleterious process (such as corrosion or scale formation), but be used in a well in which that deleterious process is not  
10 occurring anyway - i.e. it has no appreciable effect on any chemical processes occurring in that well.

The invention will now be further described by way of example only, and with reference to the accompanying  
15 drawing, which shows graphically the variation of fracture conductivity with closure stress for two different types of proppant particle.

When it is desired to enhance the permeability of a  
20 formation comprising oil-bearing strata in the vicinity of an oil well, it is known to inject fluid into the well such that the pressure at the depth of those strata is sufficient to cause of fracturing of the rocks of the strata. The fluid injected into the rocks may contain a  
25 dissolved polymer which may be cross-linked to form a gel (so it is of high viscosity), and contains proppant particles which are carried into the fractures by the injected fluid. When the pressure is reduced the particles prevent the fractures closing. Typically the  
30 fractures extend over 20 m out from the well bore, often in excess of 100 m, and the proppant particles will be distributed throughout the length of every fracture.

This embodiment of the invention uses, as the  
35 proppant particles, porous alumino-silicate ceramic beads of porosity about 6 percent and of size 16/20 mesh (0.85

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- 1.2 mm). The beads are coated and impregnated with a scale inhibitor chemical in solid form. This may be done by substantially the same procedure as that described in GB 2 298 440 A, as follows:

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(i) concentrated aqueous solution of scale inhibitor is made from a commercially-available diethylene-triamine penta-(methylenephosphonic acid)-based scale inhibitor (initially about 25 percent active material), by first adding to this inhibitor 5000 to 10 25,000 ppm cations (calcium and magnesium) added as chlorides, preferably 12,000 to 25,000 ppm, and then distilling under vacuum to about half the initial volume. The pH is adjusted to a value in the range pH 6.0 to pH 15 11.0 by acting concentrated sodium hydroxide, preferably to pH 10.

(ii) the ceramic beads are placed in a pressure vessel, and the vessel evacuated to about 0.1 mbar (10 20 Pa) absolute to ensure that no air or vapours remain in the pores. The vessel is then filled under vacuum with the concentrated inhibitor. After quarter of an hour the vacuum is released, the vessel drained, and the wet beads removed.

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(iii) the wet beads are then dried in an oven or a fluidised bed, so that they contain the scale inhibitor in a solid form.

30 If such beads are used as proppants then, in those parts of the fracture in which water flows, the permeability will decrease, because the water will dissolve the scale inhibitor from the surface of the beads. This decrease in permeability is illustrated in 35 the figure, to which reference is now made. This shows graphically the fracture conductivity when using such

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beads containing solid scale inhibitor (graph A) and the fracture conductivity if all the scale inhibitor has dissolved from such beads (graph B). The fracture conductivity values are given in millidarcy feet (1 md ft =  $0.3 \times 10^{-15} \text{ m}^3$ ) and the closure stresses in psi (1000 psi = 6.8 MPa). In both cases the conductivity decreases at higher closure stresses, but for all closure stresses above about 3000 psi the fracture conductivity is noticeably less once the inhibitor has dissolved (graph B).

The decrease in fluid conductivity as the scale inhibitor dissolves is the result of two mechanisms. Firstly, the dissolution of the scale inhibitor from the external surface of the beads reduces their diameter, so lowering the conductivity. Secondly, the dissolution of the scale inhibitor from the surface and the pores weakens the beads so they are less able to withstand the closure stress, and they generate fines, which also lowers the fluid conductivity. For example experimental tests at a closure stress of 5000 psi found that the beads containing scale inhibitor generated about 10 percent fines, whereas the beads containing no scale inhibitor generated 28 percent fines.

It will be appreciated that the process of the invention may be performed using beads which differ from those described above. For example the ceramic beads might be substantially non-porous, with only an external coating of the solid scale inhibitor. The beads might be impregnated and coated with a different scale inhibitor, or indeed with any water-soluble chemical, for example a water-soluble polymer. It will also be understood that the size of the beads must be selected so as to ensure the beads are sufficiently strong to withstand the closure stresses in the fracture, and to provide a

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significant contrast in flow capacity between the fracture and the formation.

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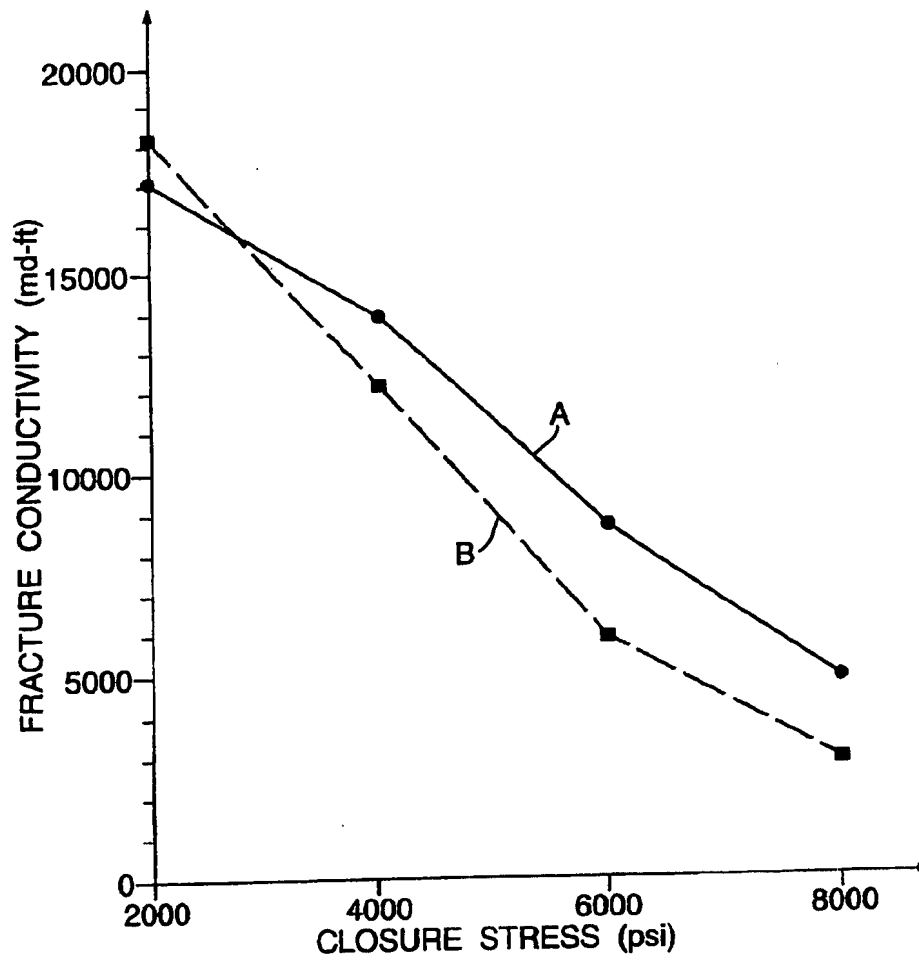
Claims

1. A method of treating an oil or gas well so as to reduce the proportion of water produced by the well, the  
5 method comprising subjecting the well to a fracture treatment with proppant particles whose conductivity decreases when they are contacted by water.
2. A method as claimed in claim 1 in which the proppant  
10 particles are coated on their external surfaces with a water-soluble chemical.
3. A method as claimed in claim 1 or claim 2 in which the proppant particles are porous and are impregnated  
15 with a water-soluble chemical.
4. A method as claimed in claim 2 or claim 3 in which the water-soluble chemical is one which has no appreciable effect on any chemical processes within any  
20 well.
5. A method as claimed in claim 2 or claim 3 in which the water-soluble chemical is a scale inhibitor.
- 25 6. A method as claimed in any one of the preceding claims in which the particles are of a ceramic material, and are of size in the range 0.3 mm to 5 mm, more preferably between 0.5 mm and 2.0 mm, for example about 0.5 mm or about 1.0 mm.

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# INTERNATIONAL SEARCH REPORT

International Application No  
PCT/GB 99/01125

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 6 E21B43/267 E21B33/138

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 193 369 A (EXXON CHEMICAL PATENTS INC) 3 September 1986 see page 2, line 4 - line 32 see page 3, line 17 - page 4, line 16 see page 5, line 22 - page 6, line 16	1-5
X	US 5 422 183 A (A.R.SINCLAIR) 6 June 1995 see column 1, line 12 - line 42	1
X	US 4 518 039 A (J.W.GRAHAM) 21 May 1985 see column 1, line 22 - line 48	1
X	US 5 420 174 A (B.DEWPRASHAD) 30 May 1995 see column 1, line 8 - column 2, line 15	1

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

### \* Special categories of cited documents :

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# INTERNATIONAL SEARCH REPORT

information on patent family members

Int'l Application No

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